Achieving Low-Pressure Cogeneration with DOWTHERM Heat Transfer Fluids

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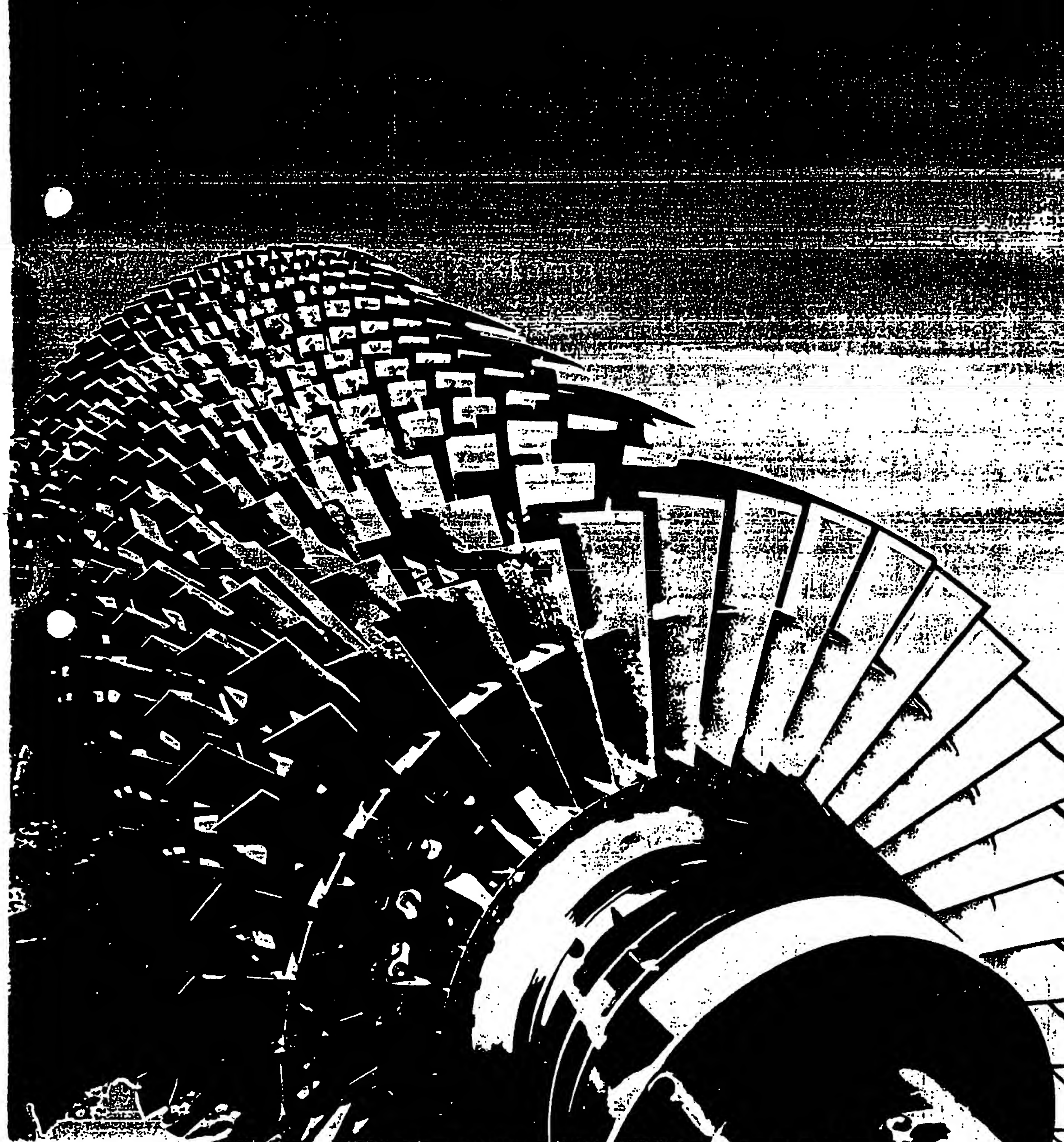

Innovative low-pressure energy systems rely on DOWTHERM* Heat Transfer Fluids

Cogeneration is not a new idea, but is a proven energy conservation tool based upon sound engineering principles. Recently, however, interest in the concept has increased significantly largely due to the economic incentives made available to industrial users and entrepreneurs alike.

Whether based upon steam turbines, gas turbines, or a combination of both, cogeneration can achieve an increase of up to fifty percent in fuel efficiency over conventional power plants and steam generators. In addition, efficient cogeneration can be achieved by the combination of a gas turbine (or any hot flue gas source) and low-pressure organic fluid energy systems.

The economic incentives made available over the past few years include:

1) The Public Utility Regulatory Policy Act (PURPA), of 1978, now requires utilities to buy back excess power generated by in-plant systems, moving such systems toward a "profit center" status;

2) Cogeneration with a gas turbine system is less capital intensive; is easier and faster to install; lead time from conception to implementation is much shorter than for conventional power plants; components approach "off-the-shelf" status in availability;

3) A company has more time to project load growth needs, eliminating the necessity of early — and often excessive — commitments to large capital expenditures;

4) Companies can now be more independent of utilities by generating much of their own power often at lower rates than those charged by utilities.

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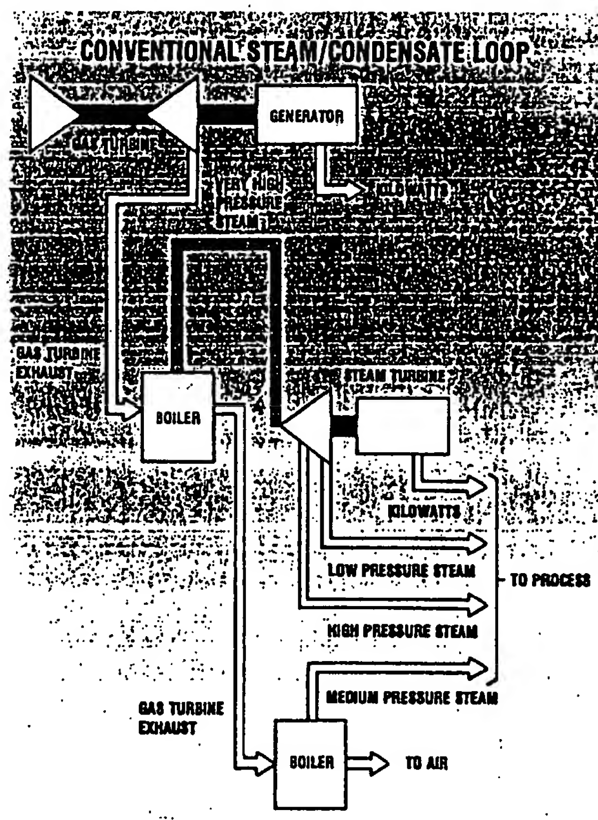
DOWTHERM Fluids are the key to low-pressure cogeneration

Typically, three methods are used to satisfy the need to up-grade the efficiency of a gas-fired turbine: direct use of hot flue gas; steam generation; energy cycles using DOWTHERM fluids. The most common method is steam generation, which is usually coupled with the production of electrical energy by means of a steam turbine, as shown in Figure 1.

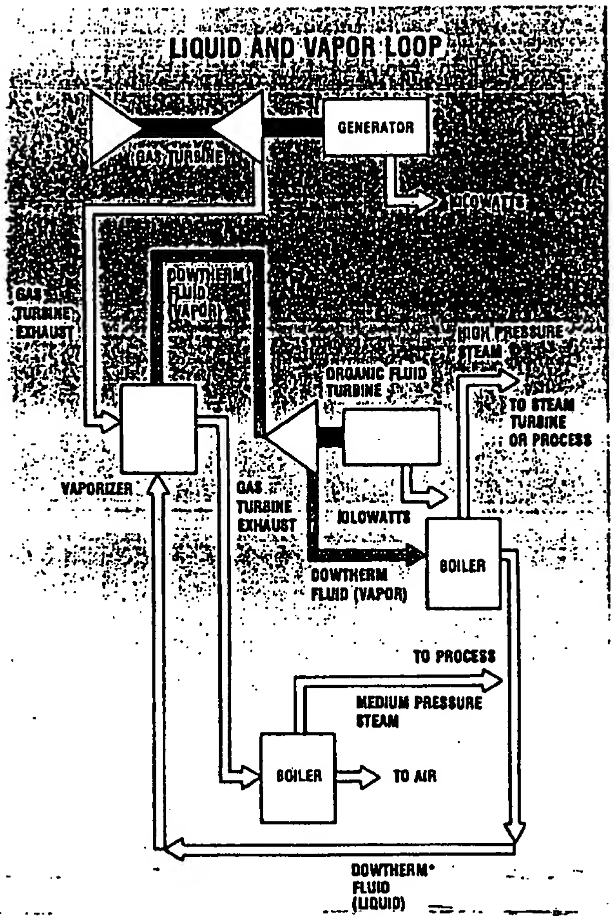
Figure 1. Cogeneration with combined gas/steam turbines.



DOWTHERM heat transfer fluids used in conjunction with gas-fired turbines offer an attractive alternative to the combined gas turbine/steam generation cycle, as illustrated in Figure 2. The low-pressure option made available with a DOWTHERM fluid is the cornerstone in the evaluation of this alternative cogeneration system.

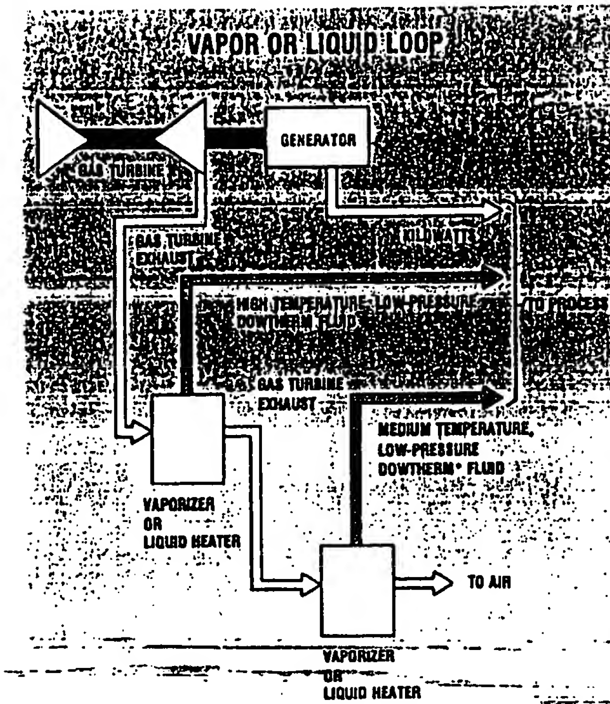
Where the corresponding steam pressure generated in the conventional system exceeds 500 psig, this low pressure alternative provides special advantages.

Figure 2. Cogeneration with combined gas turbine/organic fluid; eliminates very high-pressure steam loop.



DOWTHERM heat transfer fluids are also ideal candidates for use in bottoming cycles, such as the one shown in Figure 3. These fluids have been proven successful in this special high-temperature application on numerous off-shore drilling platforms for several years. The utilization of DOWTHERM fluids for this application closely complements our long history of providing a source of thermal energy for processes requiring temperatures at or above 500°F.

Figure 3. Cogeneration with combined use of gas turbine and DOWTHERM Fluids.



Advantages of using DOWTHERM Heat Transfer Fluids add up quickly

1) Lower Operating Pressures
A typical steam generating cycle coupled to a gas-fired turbine is usually designed to operate with superheated steam at 700°F, and with pressures exceeding 1,000 psig. DOWTHERM A heat transfer fluid, on the other hand, has a vapor pressure of only 91.1 psig at 700°F. This lower operating pressure permits the use of low-pressure piping instead of the more costly, hard-to-install, special alloy high pressure steam piping materials. The over-all result is much lower costs for welding, pipe support, relief valves, and installation.

2) Design Flexibility
As shown in Figures 2 and 3, the use of DOWTHERM fluids permits a range of design options which help in making cogeneration efficient and profitable in power generation; liquid phase heating; vapor phase heating; any combination of these.

3) Simplified Pump Requirements
Standard, off-the-shelf centrifugal pumps can be readily incorporated in a system using DOWTHERM fluids. But in a system requiring very high pressure steam generation, multi-stage pumps must be specified to meet excessive head requirements. Not only are basic pump costs lower with a system using DOWTHERM fluids, but the energy required to operate the pumps is drastically reduced, as well.

4) Non-Corrosive
All high temperature DOWTHERM fluids are non-corrosive toward most common materials and alloys used in the construction of equipment. Even at very high operating temperatures, equipment using DOWTHERM fluids will experience an excellent service life.

5) Excellent Chemical Stability
DOWTHERM fluids are chemically stable and resistant to changes in pH when used properly in nitrogen-blanketed, closed systems and within the recommended temperature range. No chemical additives are required to buffer the fluid, so there's no need for sophisticated fluid monitoring equipment.

6) **Unsurpassed Thermal Stabil...**

With DOWTHERM fluids, normal degradation products won't cause excessive mechanical problems. That's because the degradation products formed with DOWTHERM fluids are *soluble,* providing they do not exceed specified concentrations.†

Heat transfer equipment remains free of deposits when DOWTHERM fluids are used properly. Contrary to water-based systems, no chemical additives are required to prevent deposits of insoluble materials on heat transfer equipment.

Whatever the technology, cogeneration systems face common problems

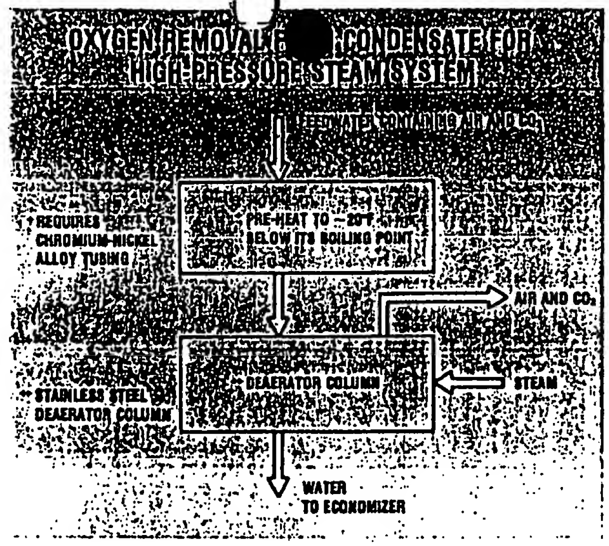
Given the temperatures at which both conventional and low pressure cogeneration systems must operate, certain common problems must be faced. The two technologies are similar, as are the problems. However, those encountered in low pressure systems using DOWTHERM fluids are likely to be less severe than those found in conventional systems. Some of the most common problems arising in *either* system include:

1) **Loss of Condensate/Liquid Circulation**
When mechanical or power failures occur, circulation of the energy recovery fluid (DOWTHERM fluid or steam/condensate) may be lost. When this happens, temperatures of the flue gas reaching the energy recovery equipment will be excessive. This quickly results in potentially irreparable damage to the heat exchanger due to metal failure. This problem is essentially identical for both systems. Sound engineering technology and practices are available to assure protections of the heat exchanger, regardless of which cogeneration system is being considered.

2) **Oxygen Contamination of Energy Recovery Media**
Even DOWTHERM heat transfer fluids are susceptible to accelerated degradation in the presence of oxygen at elevated temperatures. When a DOWTHERM fluid is involved, however, oxygen removal is a simple process, typically requiring only circulation through an inexpensive expansion tank located in the pump suction piping. A nitrogen pad is employed to insure that once the system is free of dissolved oxygen it will remain so.

Steam/condensate systems, on the other hand, must be maintained in a condition that is free of oxygen and carbon dioxide to guard against corrosion of carbon steel heat recovery equipment. These degasification processes require investment in expensive stainless steel preheating exchangers, coupled with costly stripping columns.

†Contamination or extreme overheating can lead to excessive degradation including a potential for carbon deposits. For specific information about the thermal stability of DOWTHERM heat transfer fluids, see Dow literature form no. 176-1373-83.



Low pressure cogeneration is the "process with promise" for today's energy conservation needs. It simplifies the design of the system as well as handling many of the operational problems that arise. One of the keys to successful operation is in the selection of a DOWTHERM heat transfer fluid. These organic fluids are backed by Dow's fifty years of experience in the engineering and manufacturing of quality synthetic aromatic fluids. We are able to help our customers select the right fluid for their application, then assist them in achieving full efficiency in its use through in-depth technical service. Leadership in the marketplace proves DOWTHERM heat transfer fluids "deliver".

Heat transfer fluid precautions

Flammability
DOWTHERM heat transfer fluids are combustible materials which have fire points ranging from 155° to 375°F. This is clearly a design parameter which must be considered in regard to equipment design, selection, and layout, and which does not apply in the conventional steam/condensate cycle. These fire point characteristics, along with the fluids' tendency to oxidize at temperatures exceeding the flash point demand closed loop operation and possibly inert gas blanketing. The maximum operating temperatures required for the organic fluids in the concepts proposed in Figures 2 and 3 are no more severe than the temperatures encountered in a wide variety of industries which have employed DOWTHERM heat transfer fluids for decades. Thus, if used and maintained properly, installations employing DOWTHERM heat transfer fluids can result in fire-safe operation.

Health and Environmental Concerns
When used as heat transfer media, DOWTHERM fluids should present no serious pollution problem and no appreciable hazard to health when used in accordance with good operating practices. It should be noted, however, that provisions must be made to avoid significant discharge of these fluids into public waters. Contact Dow sales offices for more complete information.

Significant Properties† of the Five Types of DOWTHERM Heat Transfer Fluids

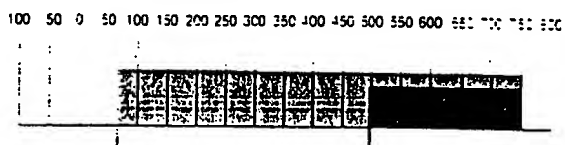
		DOWTHERM A	DOWTHERM G	DOWTHERM LF	DOWTHERM J	DOWTHERM HT
Composition		73.5% Diphenyl oxide 26.5% biphenyl	Mixture of di- and tri- aryl ethers	Aromatic blend	Alkylated aromatic	Partially Hydrogenated Terphenyl
Temperature Use Range, °F	Liquid	60 to 750	20 to 700	-25 to 600	-100 to 575	25 to 650
	Vapor	495†† to 750	—	—	358†† to 575	—
Film coefficient @ 600°F BTU/hr Ft² °F		680	566	610	880	580
Vapor Pressure psig	at Max. use temperature	137.8	40.3	20.7	128.8	0.0
Thermal Conductivity Liquid BTU/(HR)(Ft²) (°F./FT)	Min. use temperature	0.082	0.079	0.085	0.081	0.072
	at Max. use temperature	0.0545	0.055	0.0580	0.0635	0.061
Specific Heat Liquid BTU/(lb) (°F)	Min. use temperature	0.374	0.36	0.36	0.384	0.33
	at Max. use temperature	0.633	0.57	0.59	0.697	0.656
Viscosity Liquid Centipoise	Min. use temperature	6.0	147.0	84.5	10.0	2000
	at Max. use temperature	0.14	0.21	0.22	0.11	0.33
Density, Liquid Lb/Ft³	Min. use temperature	66.4	68.6	66.8	58.6	63.6
	at Max. use temperature	42.57	51.2	50.0	36.8	48.5
Freeze Point, °F		53.6	Below 40†††	Below −25†††	Below −100†††	Below −18††††
Flash Point, °F., C.O.C.		255	285	275	145	355
Fire Point, °F., C.O.C.		275	295	295	155	375
Autoignition temperature, °F., A.S.T.M.		1,139	1,083	1,020	808	662

†Properties shown are typical and should not be considered specifications
††Boiling point at atmosphere pressure
†††Crystal Point
††††Pour Point

Material Safety Data Sheets for all DOWTHERM heat transfer fluids are available from your nearest Dow sales office.

DOWTHERM A Heat Transfer Fluid

The industry's most versatile and stable organic fluid for liquid and vapor phase use. It is applicable in vapor phase operations from 495° to 750°F, and in liquid phase from 60° to 750°F, with excellent thermal stability. It is noncorrosive to metals commonly used in heat transfer systems; features low viscosity and is biodegradable.

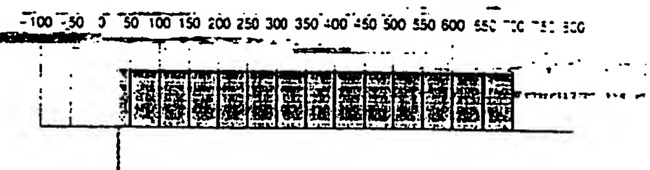


Vapor phase from 495° to 750° F.

Liquid phase from 60° to 750° F.

DOWTHERM G Heat Transfer Fluid

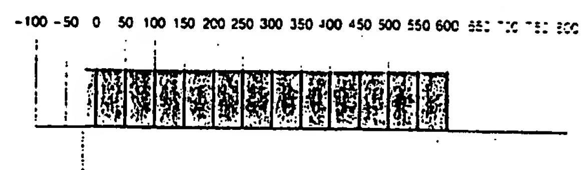
The most stable low-pressure, liquid phase organic heat transfer fluid available, even up to its maximum use temperature of 700°F. It is easily pumped at temperatures down to 20°F, eliminating startup and shutdown problems. It is low in toxicity, and noncorrosive to metals commonly used in heat transfer systems.



Liquid phase from 20° to 700° F.

DOWTHERM LF Heat Transfer Fluid

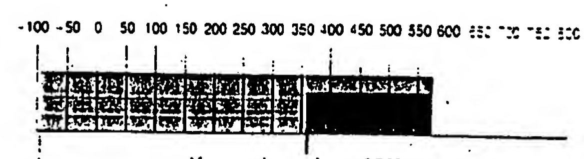
The fluid's low freeze point and low viscosity eliminates+ pipeline tracing in colder climates. It remains liquid down to -25°F, at which it has a viscosity of only 84.5 cps, and is easily pumped after shutdown and cooling. Its vapor pressure of 21.0 psig at 600°F allows use in low pressure liquid systems. It is noncorrosive to metals commonly used in heat transfer systems.



Liquid phase from -25° F to 600° F.

DOWTHERM J Heat Transfer Fluid

The ideal fluid for demanding applications from -100° to 575°F in liquid phase pressurized systems. In vapor phase, it works equally well from 358° to 575°F. Thermal stability is excellent in both uses. Its extremely low freeze point (-100°F) eliminates+ any need for pipeline tracing. It is noncorrosive to metals commonly used in heat transfer systems.

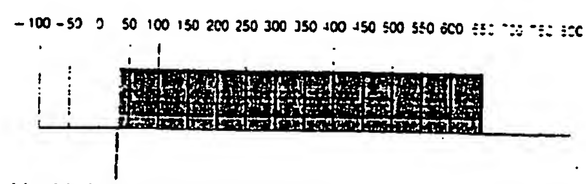


Vapor phase from 358° to 575° F.

Liquid phase from −100° to 575° F.

DOWTHERM HT Heat Transfer Fluid

This fluid displays good thermal stability characteristics across its entire use range of 25° to 650°F. Its principal advantage is its high boiling point (650°F) allowing for low system operating pressures. It is low in toxicity, possesses only faint odor characteristics and is non-corrosive to metals commonly used in heat transfer systems.



Liquid phase from 25° F to 650° F.

+Vent lines will require tracing

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